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Optimalization of Outpit Dump at Asam-Asam Open Pit Coal Mine, PT Arutmin Indonesia

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PT Arutmin Indonesia (PTAI) has a mine site located in Asam-Asam region. There is approximately 52 million-ton reserve of low-rank coal. The failure occurred in the overburden dumping area 1-2 DH on March 2012 and further dumping is still planned in this area. Therefore, a geotechnical study was conducted in order to characterize the cause of failure and to guarantee that dumping activity can be continued. Result of analysis shows that the post failure condition is in stable even though the volume of dumping material increases. However, the dumping process should be done layer by layer so that compaction process can be happened.

1. Introduction

PT Arutmin Indonesia (PTAI) is one of the Indonesian coal mining companies. One of its sites is located in Asam-Asam region, Banjarmasin (see Fig. 1). Asam-Asam Coal consists of six major seams which are seam B until seam G. The thickness of their coal seams varies from 2-25 m with strike of N70°E and dip around 25°-35°. Asam-asam coal mine has approximately 52 million ton reserve of low rank coal at a relatively low stripping ratio which is around 4.67.

Low rank coal is categorized as a marginal coal deposit. Moreover its price has been dropped down around $60 recently. Consequently mining operation at Asam-Asam mine site has to be optimized in order to reduce mining cost. One of the measures is to reduce haulage distance of overburden removal activity. As the consequences, overburden dumping in Asam-Asam coal mine is located near lowwall area and the mining front.

One of overburden dumping area in Asam-Asam site is outpit dump DH 1-2 (OPD DH 1-2). This overburden dump height is around 25 meter. Failure has occurred in this overburden dump on March 2012 as shown in Fig. 2. Currently, PTAI is planning to continue coal mining operation in Pit 1-2 DH. Since an optimization of hauling distance is needed, the availability of OPD DH 1-2 is very important for pit 1-2 DH dumping area. Therefore, a geotechnical study has to be conducted in order to characterized the cause of failure occurred in OPD pit 1-2 DH and to guarantee that OPD pit 1-2 DH can be used for further dumping activity.

The numerical analysis is conducted by using the limit equilibrium method which is Janbu method[1)] for composite failure analysis using computer program Slide ver 3.0 developed by Rocscience. A simulation by applying weak material at base of outpit dump is carried out in order to know the effect of the weak material on the stability of dumping area[2,3)]. The slope stability analysis was conducted in cross sections as representative of the site condition.

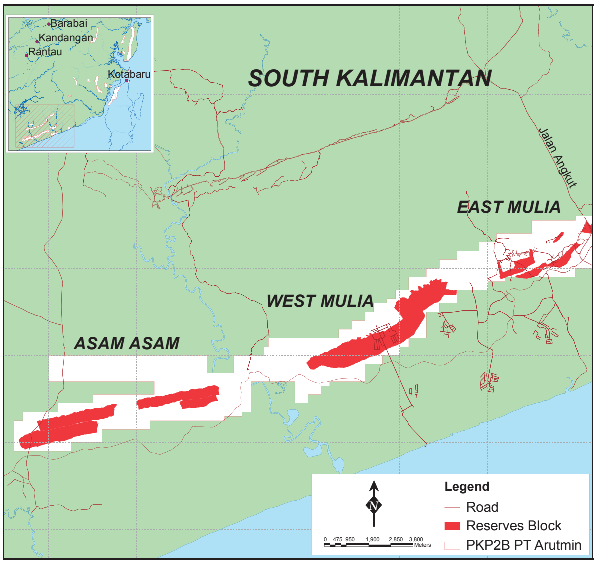


Fig. 1 Investigation area.

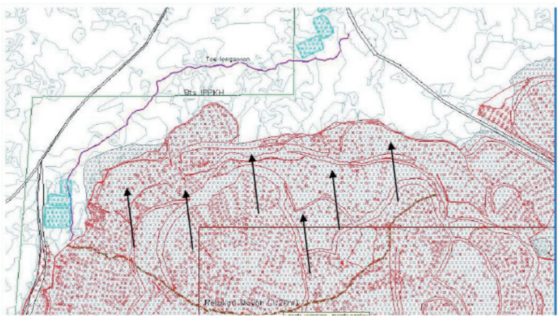


Fig. 2 OPD pit 1-2 DH and direction of failure.

2. Site investigation

Material of OPD Pit 1-2 DH is overburden from Pit 1-2 DH which mudstone and sandstone are dominated. It is calculated from surveying that approximately 6 million cubic meter material is slide with around 400 m width and 900 m length. Geometry of sliding area is shown in

Fig. 3.

The type of failure is predicted as a composite failure consists of plane failure and circular one, and the sliding plane based on field observation is represented by the dash line in Fig. 3. It is also known that dumping activity is carried out by using free dump technique without a proper compaction in some of OPD Pit 1-2 DH.

All of samples obtained from the Standard Penetration Test of Asm-SPT1101 and Asm-SPT-1103 have been tested in laboratory in order to obtain physical and mechanical characteristics of rock forming OPD Pit 1-2 DH. Physical and mechanical characteristics of each material obtained from laboratory test carried out on Asm-SPT1101 and Asm-SPT-1103 is shown at Table 1.

Based on the result of site investigation, it is found that a weak layer is lying at base of dump material which is swamp material. It is also found that this material is in wet condition due to submerged by water for a long time. All physical and mechanical properties from laboratory test on geotechnical borehole Asm-SPT1101 and Asm-SPT-1103 will be used for the following numerical study for the stability of OPD Pit 1-2 DH.

3. Outpit dump stability analysis

The calculation of slope stability analysis was based on limit equilibrium using Janbu method for composite failure analysis[1]. Slope stability analysis in OPD Pit 1-2 DH section before failure was conducted in order to determine the failure mechanism. Cross section 2 as shown in Fig. 4 is analyzed for this purpose. Physical and mechanical characteristics of OPD Pit 1-2 DH as shown in Table 1 is used for this analysis. The result is shown in Fig. 5a. Based on this figure, it is found that OPD Pit 1-2 DH is in stable condition and this result is different with the actual field condition. Therefore, it might be caused by the reduction of material strength due to their deterioration. In order to estimate the parameter of material after deteriorating, back analysis was conducted and the weak layer's parameters were obtained from trial and error back analysis. The cohesion and internal friction angle are 1 kPa and 12.8 deg., respectively

Fig. 5b show the result of analysis for OPD Pit 1-2 DH before failure from composite failure possibility using back analysis material for weak layer at the base of inpit dump as shown in Table 2.

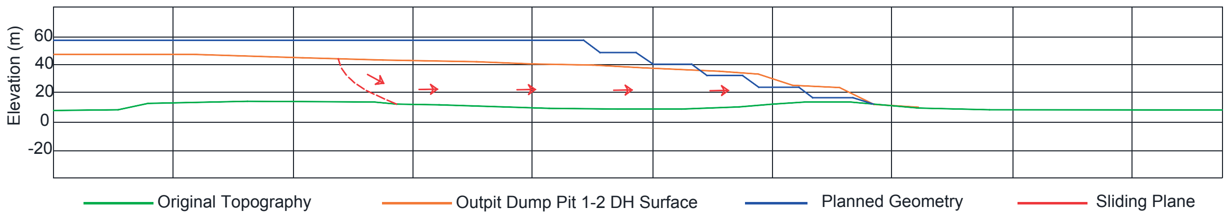


Fig. 3 Geometry of failure at OPD pit 1-2 DH.

Table 1 Physical and mechanical characteristics of dumping material[4)]

Asm-SPT 1101				Asm-SPT 1103			
Material	ρ_{sat}(gr/cm^3)	C (kPa)	ϕ (°)	Material	ρ_{sat}(gr/cm^3)	C (kPa)	ϕ (°)
Dump	1.90[1]	46[1]	12.80[1]	Dump	1.90[1]	46[1]	12.80[1]
Spt1	1.80[1]	80[3]	12.80[1]	Spt1	1.80[1]	34[4]	12.80[1]
Spt2	1.80[1]	200[3]	12.80[1]	Spt2	1.80[1]	80[4]	12.80[1]
Spt3	1.80[1]	250[3]	12.80[1]	Spt3	1.80[1]	154[4]	12.80[1]
Spt4	1.80[1]	193[3]	12.80[1]	Spt4	1.80[1]	154[4]	12.80[1]
Spt5	1.80[1]	180[3]	12.80[1]	Spt5	1.80[1]	120[4]	12.80[1]
Spt6	1.80[1]	187[3]	12.80[1]	Spt6	1.80[1]	274[4]	12.80[1]
Spt7	1.80[1]	227[3]	12.80[1]	Spt7	1.80[1]	260[4]	12.80[1]
Spt8	1.80[1]	320[3]	12.80[1]	Spt8	1.80[1]	294[4]	12.80[1]
base	1.80[1]	175[2]	26.95[2]	base	1.80[1]	175[2]	26.95[2]

Source:
[1]Table 3.8 of Final Report Stability Analysis of Final Highwall in Asam-Asam and Mulia Mine PT Arutmin Indonesia
[2]Table 4.5 of Final Report Stability Analysis of Final Highwall in Asam-Asam and Mulia Mine PT Arutmin Indonesia
[3]Geotechnical Drilling Report Asm-SPT 1101
[4]Geotechnical Drilling Report Asm-SPT 1103

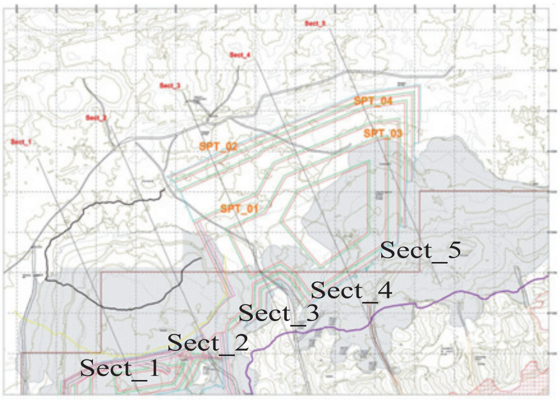
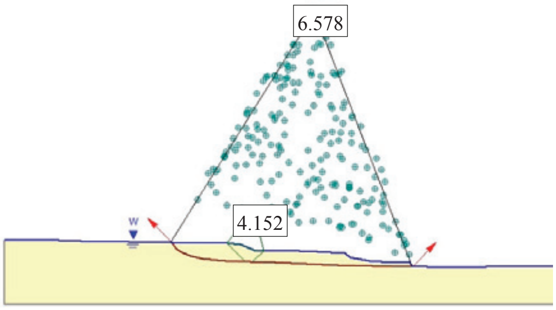
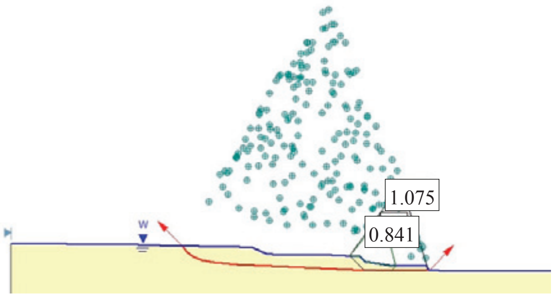


Fig. 4 Cross section line location.



(a)



(b)

Fig. 5 Analysis of OPD pit 1-2 DH (a) using SPT test material (SF =4.15); (b) using back analysis material (SF=0.84).

Table 2 Physical and mechanical characteristics of failure area OPD pit 1-2 DH [4,5]

Material	ρ_{sat}(gr/cm^3)	C (kPa)	ϕ (°)
Dump Material	1.90	46	12.80
Soft Base Material	1.90	1[1]	12.80
Hard Base Material	1.80	175	26.95

Note: [1]Based on back analysis

Based on the result of analysis, it can be known that a failure occurs only at the front side of OPD Pit 1-2 DH. Providing that front side material moving forward after failure occurred, stability analysis can be conducted by omitting front side material as shown in Figs. 6 and 7. It can be seen the large failure at material pile was induced by the failure of front side material.

By using surface condition after failure and using the same sliding plane, post failure analysis is then conducted in order to know the stability of outpit dump after failure. Result of analysis can be seen in Fig. 8. From the result of post failure analysis it can be known that post failure at OPD pit 1-2 DH is in stable condition. However, in order to obtained higher certainty of stability, resloping is still conducted. Fig. 9a shows the actual field condition of OPD Pit 1-2 DH after resloping activity is conducted

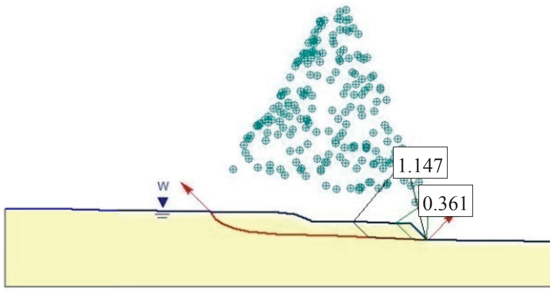


Fig. 6 Result of outpit dump failure analysis by omitting the front side material (SF = 1.147).

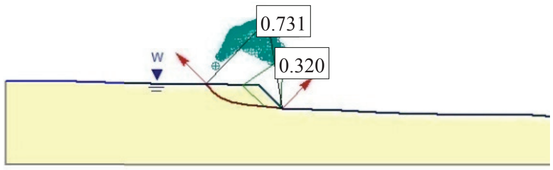


Fig. 7 Result of outpit dump failure analysis at center side by omitting the front side material (SF=0.73).

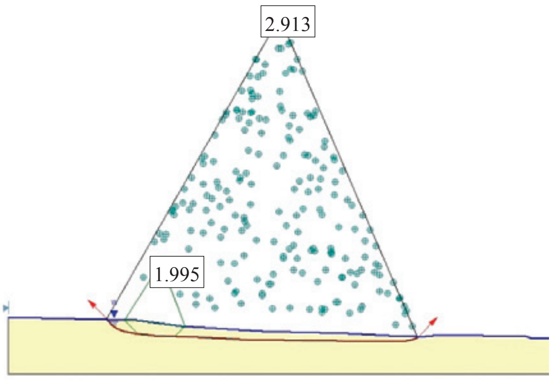


Fig. 8 Result of OPD pit 1-2 DH failure analysis at block 10 after failure (SF=1.995).

(a)

(b)

Fig. 9 Field condition of OPD pit 1-2 DH after resloping activity (a) in June 2012; (b) in October 2012.

in June 2012 while Fig. 9b shows its condition in October 2012. Based on the result of further field investigation OPD pit 1-2 DH is in stable condition which is in a good correlation with the numerical analysis on post failure condition of Pit 1-2 DH.

For optimizing the mining activity, OPD Pit 1-2 DH is still needed as a short range dumping area. In order to optimize OPD pit 1-2 DH after failure, Post failure analysis with the addition of another dumping material from pit 1-2 DH is carried out. Optimization of post failure OPD pit 1-2 DH is carried out by adding dumping material until the overall slope height is 60 meter and angle of 10° while the single slope height is 10 meter and angle of 35° with failure material act as base of Optimized OPD Pit 1-2 DH model. Figs. 10 and 11 show the result of optimized OPD Pit 1-2 in Section 3 for circular sliding analysis and composite sliding analysis. The same analysis is conducted for OPD pit 1-2 DH in section 5. The result is shown in Fig. 12.

At the north side of Optimized OPD Pit 1-2 DH plan, there is a roadway which is used by local people around Asam-Asam Mine site (see Fig. 2). The distance between the roadway and the Optimized OPD pit 1-2 DH plan is around 150 meter. In order to know the deformation of optimized OPD Pit 1-2 DH numerical analysis using

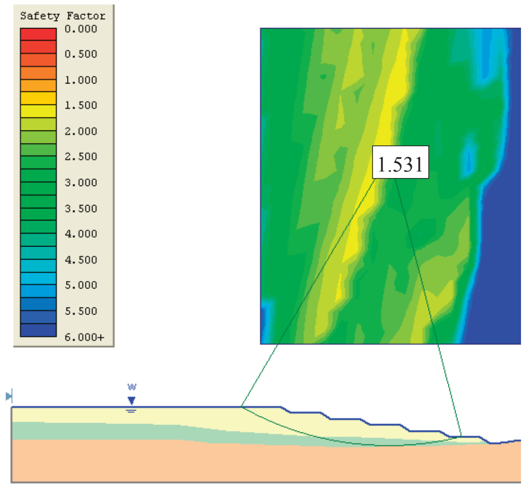


Fig. 10 Result of optimized OPD pit 1-2 DH at section 3 for circular sliding analysis (SF=1.53).

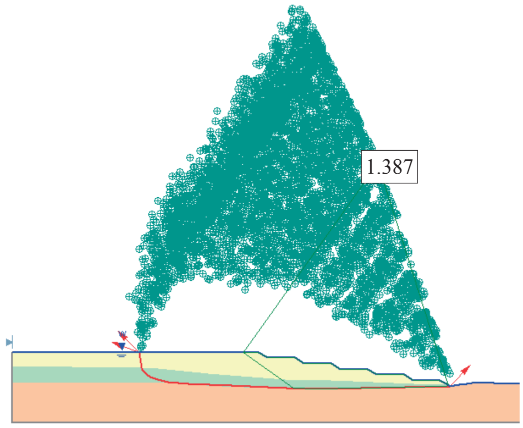


Fig. 11 Result of optimized OPD pit 1-2 DH at section 3 for composite sliding analysis (SF = 1.38).

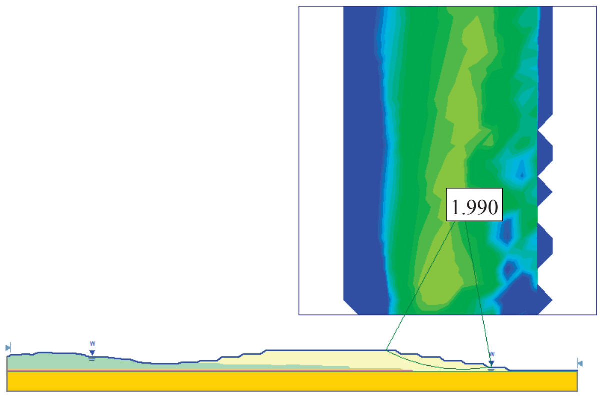


Fig. 12 Result of optimized OPD pit 1-2 DH at section 5 for circular sliding analysis (SF=1.99).

Finite Element Method is carried out. It must be ensured that the deformation should not exceed the buffer zone around 100 meter from the roadway. Numerical analysis is carried out at Section 2, Section 3 and Section 5 of Optimized Pit 1-2 DH.

Material characteristics for numerical analysis in OPD pit 1-2 DH for Sections 2, 3 and 6 are shown in Tables 3, 4, and 5 for Section 2, Section 3, and Section 5 respectively. The results of numerical analysis are shown in Figs. 13-15.

Table 3 Physical and mechanical properties for optimized OPD pit 1-2 DH analysis using finite element method in section 2 [4)]

Material	ρ_{sat}(gr/cm^3)	C (kPa)	ϕ (°)	E (MPa)	v
Dump Material	1.90[1]	46[1]	12.80[1]	130[4]	0.3[4]
Soft Base Material	1.80[1]	1[2]	12.80[1]	73[4]	0.3[4]
Hard Base Material	1.80[1]	175[3]	26.95[3]	285[4]	0.3[4]

Source:
[1]Table 3.8 of Final Report Stability Analysis of Final Highwall in Asam-Asam and Mulia Mine PT Arutmin Indonesia
[2]Based on back analysis
[3]Table 4.5 of Final Report Stability Analysis of Final Highwall in Asam-Asam and Mulia Mine PT Arutmin Indonesia
[4]Table 3.4 of Final Report Stability Analysis of Final Highwall in Asam-Asam and Mulia Mine PT Arutmin Indonesia

Table 4 Physical and mechanical properties for optimized OPD pit 1-2 DH analysis using finite element method in section 3 [4)]

Material	ρ_{sat}(gr/cm^3)	C (kPa)	ϕ (°)	E (MPa)	v
Dump Material	1.90[1]	46[1]	12.80[1]	130[4]	0.3[4]
Spt1	1.80[1]	80[2]	12.80[1]	73[4]	0.3[4]
Spt2	1.80[1]	200[2]	12.80[1]	285[4]	0.3[4]
Spt3	1.80[1]	250[2]	12.80[1]	285[4]	0.3[4]
Spt4	1.80[1]	193[2]	12.80[1]	285[4]	0.3[4]
Spt5	1.80[1]	180[2]	12.80[1]	285[4]	0.3[4]
Spt6	1.80[1]	187[2]	12.80[1]	285[4]	0.3[4]
Spt7	1.80[1]	227[2]	12.80[1]	285[4]	0.3[4]
Spt8	1.80[1]	320[2]	12.80[1]	285[4]	0.3[4]
base	1.80[1]	175[3]	26.95[3]	285[4]	0.3[4]

Source:
[1]Table 3.8 of Final Report Stability Analysis of Final Highwall in Asam-Asam and Mulia Mine PT Arutmin Indonesia
[2]Geotechnical Drilling Report Asm-SPT 1101
[3]Table 4.5 of Final Report Stability Analysis of Final Highwall in Asam-Asam and Mulia Mine PT Arutmin Indonesia
[4]Table 3.4 of Final Report Stability Analysis of Final Highwall in Asam-Asam and Mulia Mine PT Arutmin Indonesia

Table 5 Physical and mechanical properties for optimized OPD pit 1-2 DH analysis using finite element method in section 5 [4)]

Material	ρ_{sat}(gr/cm^3)	C (kPa)	ϕ (°)	E (MPa)	v
Dump Material	1.90[1]	46[1]	12.80[1]	130[4]	0.3[4]
Spt1	1.80[1]	34[3]	12.80[1]	73[4]	0.3[4]
Spt2	1.80[1]	80[3]	12.80[1]	285[4]	0.3[4]
Spt3	1.80[1]	154[3]	12.80[1]	285[4]	0.3[4]
Spt4	1.80[1]	154[3]	12.80[1]	285[4]	0.3[4]
Spt5	1.80[1]	120[3]	12.80[1]	285[4]	0.3[4]
Spt6	1.80[1]	274[3]	12.80[1]	285[4]	0.3[4]
Spt7	1.80[1]	260[3]	12.80[1]	285[4]	0.3[4]
Spt8	1.80[1]	294[3]	12.80[1]	285[4]	0.3[4]
base	1.80[1]	175[2]	26.95[2]	285[4]	0.3[4]

Source:
[1]Table 3.8 of Final Report Stability Analysis of Final Highwall in Asam-Asam and Mulia Mine PT Arutmin Indonesia
[2]Table 4.5 of Final Report Stability Analysis of Final Highwall in Asam-Asam and Mulia Mine PT Arutmin Indonesia
[3]Tabel Geotechnical Drilling Report Asm-SPT 1103
[4]Table 3.4 of Final Report Stability Analysis of Final Highwall in Asam-Asam and Mulia Mine PT Arutmin Indonesia

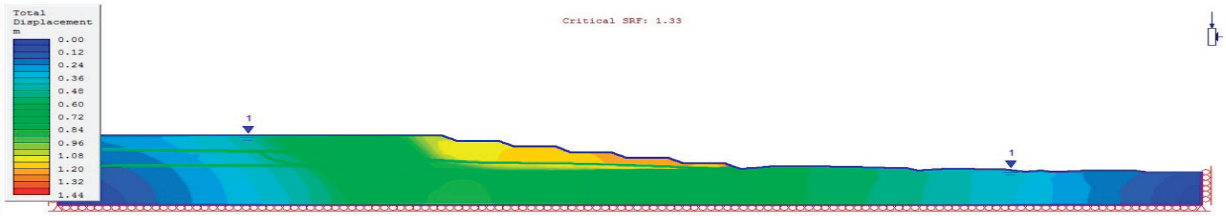


Fig. 13 Result of optimized OPD Pit 1-2 DH analysis using Finite Element Method at section 2 (SRF=1.33).

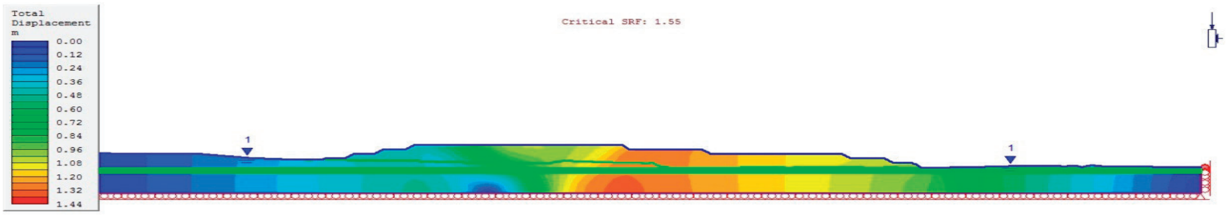


Fig. 14 Result of optimized OPD Pit 1-2 DH analysis using Finite Element Method at section 3 (SRF=1.55).

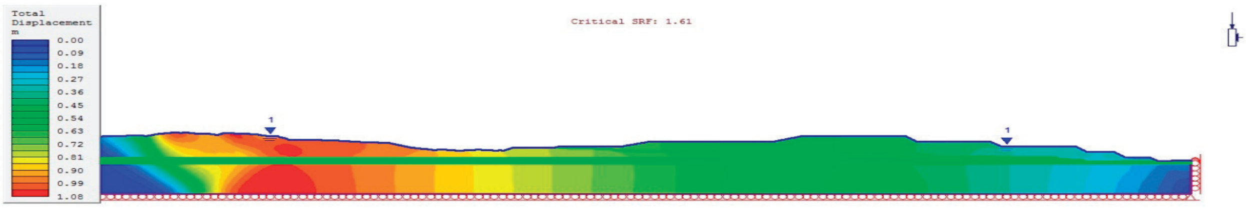


Fig. 15 Result of optimized OPD Pit 1-2 DH analysis using Finite Element Method at section 5 (SRF=1.41).

Deformation obtained by numerical analysis using Finite Element Method shows that no more than 1.32 meter of deformation will occur at the OPD pit 1-2 DH. Therefore, based on analysis of optimized OPD Pit 1-2 DH in sections 2, 3 and 5 it can be understood that the optimized design for OPD Pit 1-2 DH can be applied. However, it must be noted that dumping process should be done layer by layer so that compaction process can be happen and water contained inside of the swamp material can be drained by the compaction process. Moreover, in order to ensure safety dumping operation, after re-sloping the dumping material pile at failure area, PTAI has installed some monitoring point as shown in Fig. 16 which is monitored continuously.

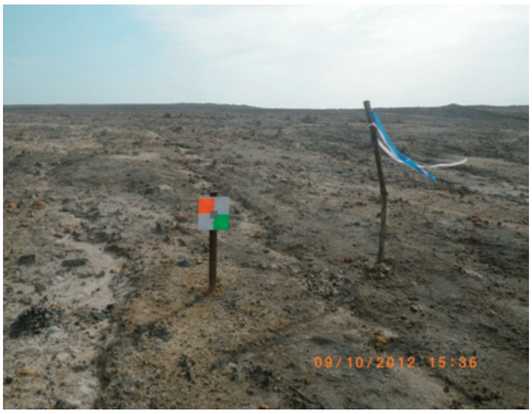


Fig. 16 Monitoring point in OPD pit 1-2 DH.

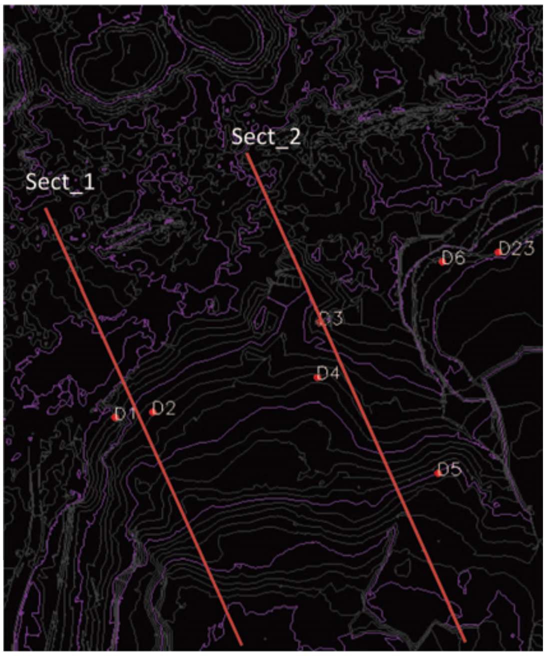


Fig. 17 Location of monitoring point in OPD pit 1-2 DH after resloping is carried out.

Fig. 18 Movement of D3, D4, and D5 monitoring points in OPD pit 1-2 DH.

Fig. 17 shows the position of monitoring point around sections 1 and 2. Monitoring data collection is carried out between early November and late December. Based on analysis using monitoring data, it can be understand that movement of points D3, D4 and D5 are eastward rather than northward. It might be due to the existence of pond. The result of movement is shown in Fig. 18. From Fig. 18, it can be confirmed that a relatively small deformation is occurred as predicted by numerical calculation using Finite Element Method.

4. Conclusions

Failure occur at OPD Pit 1-2 DH is caused by deterioration of its material and soft base lying underneath the OPD Pit 1-2 DH. The results of a series of analysis show that at the beginning, the failure occurred only around the front side of dumping area. However, since the material is deteriorated, a failure developed until the center side of dumping area. Based on the result of post failure analysis, it can be found that ODP Pit 1-2 DH is in stable condition and can be continued as dumping area for mining activity in Pit 1-2 DH until reaching 60 m height with the assist of monitoring.

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